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FINAL REPORT

EMI INSTRUMENTATION
REQUIRED FOR
THE EMCARD PROGRAM

REPORT NO. 79114
28 SEPTEMBER 1979

PREPARED FOR:

Naval Air Development Center
Warminster, PA
Contract No. N62269-79-M-6496

PREPARED BY:

R & B Enterprises
Plymouth Meeting, PA


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President

IF YOU HAVE OR CAN FIND REQ'D INSTRUMENTS
PLEASE CONTACT JOE LAVARO X3109
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Division of Robar Industries Inc.

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FOREWORD

This is the final report of Contract Number N62269-7M-6496. It contains the results of an effort to define MEC/EMI instrumentation required for the Navy's EMCARD program and MIL-STD-461A and 462 evaluations. The period of work performance under the contract extended from 13 Sept. 79 to 28 Sept. 79.

This report has been prepared to satisfy CDRL Data Item No. 1 following the format stated in A-5029.

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SECTION I

1.0 INTRODUCTION

The objective of this program is to determine the EMI instrumentation required by the Navy for testing in its EMCARD program and for MIL-STD-461A and MIL-STD-462 evaluations. This involved an inventory of available EMI instrumentation at NADC and research into the EMI instrumentation commercially available that will fulfill the stated requirements. The data has been compiled in tables from which recommendations have been made for the procurement of specific items. Costs (including GSA prices, when applicable) and delivery time have been included.

2.0 SUMMARY

Approximately 30 manufacturers of EMI test instrumentation and devices required in EMI test configuration have been contacted. The products of 25 of these manufacturers have been deemed appropriate for use in EMI and related tests. The required test equipment has been found to be commercially available with delivery dates generally ranging from stock to 6 months. In some limited cases, 12 month deliveries have been quoted. The only equipment not available as off-the-shelf equipment is the power amplification and radiation system required to produce 200V/M over the frequency ranges of 10KHz to 27GHz.

Tables have been developed showing the available EMI test instrumentation and products versus the applicable test requirements of MIL-STD-461A. A separate table is included for the test equipment required for MIL-HDBK-248 radiation hazards measurements.

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3.0 CONCLUSIONS

The EMI test instruments and products recommended for purchase by NADC have been divided into two categories: recommended bare minimum, and recommended preferred. These are presented in Tables 4 and 5 of Section II. The bare minimum includes the use of current NADC instrumentation, the manual operation of the instruments, limited redundancy in current probes and other devices, and limited back-up systems. The preferred list includes automatic operation of instrumentation, reasonable redundancy of certain products, and the availability of back-up and analysis equipment.

The current costs for the equipment are as follows:

Bare Minimum:

Preferred:

The costs represent current catalogue prices, GSA documents, where applicable, and many are substantiated by written quotes. It should be noted, however, that the prices are generally valid only for 90 days, and are subject to change at a later date.

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SECTION II

1. INTRODUCTION

This section includes a completed and detailed list of the recommended bare minimum and preferred EMI test equipment. It also describes the basis upon which the recommendations were made and other considerations.

2. OVERVIEW OF TABLES

2.1 TABLE 1

Table 1 is a list of EMI test instruments and products available to perform measurements to the requirements of MIL-STD-461A, Notices 1 and 2 per MIL-STD-462, Notices 1 and 2. In the preparation of this table, some preselection has been made, especially for products for which there are numerous sources, such as 10uf test capacitors. Cost, delivery and experience with the manufacturers' products were considerations in the preselection process.

The table shows the applicable MIL-STD-461/2 test method for which each product is required. It should be noted that a product may be applied on more than one test method in many cases.

The last column in Table 1 is the current price and delivery schedule for the corresponding product. Special GSA prices are shown, where applicable. These are all current prices taken from current price lists, and, in many cases, substantiated by written quotations. These quotations are retained in R & B Enterprises' files.

The number in the bracket following each manufacturer listed in the first column of Table 1 corresponds to the list of manufacturers shown in Table 6.

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2.2

TABLE 2

Table 2 is the list of EMI test instrumentation and products currently available at the Naval Air Development Center (NADC) in Warminster, PA. The equipment listed in this table forms the nucleus of the equipment which has been designated as bare minimum shown in Table 4. It also is a major part of extended capabilities offered by AILTECH as shown in Table 3.

2.3

TABLE 3

AILTECH has offered to modify NADC's existing NM-17/27 and NB-37/57 at no charge to make it part of complete automated receiving system. The additional equipment which must be purchased to complete this system is shown in Table 3. It should be noted that both Hewlett-Packard and Tektronix equipment form part of the AILTECH system.

The total price shown in Table 3 is \$166,112. This may be reduced substantially by deleting the extended range to 40GHz feature, FC-67, which costs \$50,000. However, AILTECH still wants to include the NM-67 receiver covering the frequency range of 1 to 18 GHz.

2.4

TABLE 4

Table 4 presents a list of recommended EMI test instrumentation and products which should be added to the current inventory of NADC equipment, as a bare minimum, in order to perform tests to most of the applicable requirements of MIL-STD-461A. It assumes that the entire testing operation will be manual, that there will be no duplication of products, such as current probes, antennas, etc. and that there will be no back-up system. The cost for this additional equipment is

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2.5 TABLE 5

Table 5 presents a list of recommended equipment which a fully equipped EMI test facility should have in order to perform EMI evaluations to MIL-STD-461/2. The automated features of this equipment provide considerable time and cost savings in the performance of the tests and the data reduction processes. It is not to be misconstrued as a "cadillac" facility since more expensive and complex measurement systems than those recommended exist.

2.6 TABLE 6

Equipment manufacturers which appear in all of the other tables of this report are consolidated and presented in Table 6. The addresses and telephone numbers are provided for the home offices. A comprehensive listing of local sales offices and sales representatives can be found in ITEM, EEM or other such directories.

2.7 TABLE 7

The prime sources of RF radiation hazard instrumentation are listed in Table 7, along with the measuring devices. The recommended device, manufactured by General Microwave is identified.

2.8 TABLE 8

The generation of 200 V/M across the radio spectrum of 10 kHz to 27 GHz is a very difficult and expensive proposition. Thus, the additional test equipment required to generate, radiate and measure these fields are separated and listed in Table 8.

3.0 DISCUSSION

The following discussion highlights some of the philosophy used in selecting the test equipment. Table 1 presents a large selection of EMI test instrumentation and products which are available. Tables 4 and 5 show the equipment which has been selected from Table 1.

The test instrumentation and products which NADC should have as a bare minimum are shown in Table 4. Even with this test equipment, there will still be tests per MIL-STD-461 for which equipment still is missing. The tests which cannot be performed are:

CS03

CS04

CS05

RE06

RS04

The reason these tests were omitted was in consideration of cost and the low frequency and priority in performing these tests. If it is desired to instrument to perform these tests, the required test equipment is shown in Table 1 and recommended in Table 5. RE06 instrumentation is not specified since it pertains to overhead power lines.

Special devices which must be built by the test laboratory, such as a long wire antenna, parallel plate, hand-held probes, etc. are not included. Other small devices, such as a step-down transformer, variac, etc. are not included since they are widely available, non-specialized and relatively low in cost.

The test instrumentation and products which the test facility should have to perform all tests per MIL-STD-461 are shown in Table 5. Whereas Table 4 assumes the use of present NADC

equipment (Table 2), specifically, the Singer EMI receivers, Table 5 recommends the purchase of the Electro-Metrics' receiving system. The cost of upgrading the current system as shown in Table is approximately the same as the cost of the Electro-Metrics' system. Thus, the new acquisition provides redundancy and a back-up system at practically no additional cost.

The use of a spectrum analyzer to perform measurements above 1GHz is the preferred approach. The analyzer provides adequate sensitivity and very broad frequency coverage. It is also a useful tool in resolving interference problems, and provides some redundancy with the receivers.

The radiation hazard meter (Table 7) serves two functions. One is to perform measurement per MIL-HDBK-248, and secondly, to measure the RS03 field strengths above 200MHz. The field sensors will measure the RS03 fields below 200MHz. Thus, an extra set of antennas is not required and the receivers are free for other parallel tests.

The generation of 200 volts per meter from 10kHz to 27GHz is very expensive and involves unproven test methods. Table 8 is a list of test equipment currently identified for this type of test. Logimetrics has indicated that their system will provide the required fields. However, additional studies are recommended in this area prior to the commitment of funds.

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TABLE 1. TEST EQUIPMENT FOR TESTING TO

MIL-STD-461A/462, NOTICES 1 and 2

MANUFACTURER	EQUIPMENT	MODEL	FREQUENCY RANGE	TEST MATERIAL		PRICE & DELIVERY
				TEST	PRODUCTION	
EMCO (1)	ANTENNA	3104	20MHz to 200MHz			\$695.
	ANTENNA	3101	200MHz to 1000MHz			45 days
	ANTENNA	3102	1GHz to 10GHz			"
	ANTENNA	3106	200MHz to 2600MHz			"
	ANTENNA	3105	1GHz to 12.4GHz			"
	ANTENNA	3103	100MHz to 1000MHz			"
ELECTRO-METRICS (2)	ANTENNA	RVR-25	.014MHz to 30MHz			\$990.
	ANTENNA	BIA-25	20MHz to 200MHz			60 days
	ANTENNA	LCA-25	200MHz to 1000MHz			"
	ANTENNA	RGA-50	1GHz to 12.4GHz			"
	ANTENNA	4104	20MHz to 200MHz			"
	ANTENNA	4101	200MHz to 1000MHz			"
TENSOR (3)	ANTENNA	4102	1GHz to 10GHz			"
	ANTENNA	4106	200MHz to 1500MHz			"
	ANTENNA	4105	1GHz to 12.4GHz			"
	ANTENNA	4103	100MHz to 1000MHz			"
	ANTENNA	95010-1	10kHz to 40MHz			\$485.
	ANTENNA	94455-1	20MHz to 200MHz			90 days
AILTECH (4)	ANTENNA	93490-1	200MHz to 1000MHz			"
	ANTENNA	93491-2	1GHz to 10GHz			"
	CURRENT PROBE	PCL-10	10kHz to 40MHz			\$750.
	CURRENT PROBE	PCL-25	20Hz to 50kHz			24 wks.
	CURRENT PROBE		10kHz to 110MHz			"
	CURRENT PROBE		20Hz to 50kHz			"
ELECTRO-METRICS (2)	CURRENT PROBE	91550-1	10kHz to 140MHz			\$595.
	CURRENT PROBE	91197-1	20Hz to 8MHz			8 wks.
	CURRENT PROBE	94111-1	1MHz to 1000MHz			"
	CURRENT PROBE	93686-2	30Hz to 50MHz			"
	CURRENT PROBE	F-17	300Hz to 50kHz			\$225.
	CURRENT PROBE	F-11	300Hz to 50kHz			5 wks.
AILTECH (4)	CURRENT PROBE	F-12	2kHz to 2MHz			"
	CURRENT PROBE	F-14	300Hz to 50kHz			"
	CURRENT PROBE		300Hz to 50kHz			"
	CURRENT PROBE		20Hz to 50kHz			"
	CURRENT PROBE		10kHz to 1GHz			"
	CURRENT PROBE		20Hz to 1.4GHz			"
FISCHER COMM. (5)	RECEIVER	EMC-10	20Hz to 50kHz			\$450.
	RECEIVER	EMC-25	10kHz to 1GHz			8 wks.
	RECEIVER	EMC-50	1GHz to 12.4GHz			"
	RECEIVER SYSTEM	FSS-250	20Hz to 1GHz			"
	RECEIVER SYSTEM	FSS-500	1GHz to 12.4GHz			"
	RECEIVER SYSTEM	FSS-750	20Hz to 12.4GHz			"
ELECTRO-METRICS (2)	RECEIVER	CCS-750	20Hz to 12.4GHz			\$104,000
	RECEIVER	CCS-125	20Hz to 1GHz			90 "
	RECEIVER		20Hz to 50kHz			"
	RECEIVER		10kHz to 1GHz			"
	RECEIVER		20Hz to 1.4GHz			"
	RECEIVER		1GHz to 12.4GHz			"

TEST EQUIPMENT FOR TESTING TO MIL-STD-461A/462, NOTICES 1 and 2 (Continued)

MIL-STD-461A/462, NOTICE 1 and 2

(Continued)

TABLE 1: TEST EQUIPMENT FOR TESTING TO

MIL-STD-461A/462, NOTICES 1 and 2 (Continued)

MANUFACTURER	EQUIPMENT	MODEL	FREQUENCY RANGL	TEST METHOD	PRICE & DELIVERY
HEWLETT-PACKARD (7)	MAIN FRAME / DISPLAY	141T	Storage Scope		
	IF SECTION	8552B	20Hz to 300kHz		
	RF SECTION	8556A	1kHz to 110kHz		\$4025
	RF SECTION	8555B	10MHz to 40GHz		\$2525
	RF SECTION	8555A			\$3350
	PRESELECTOR	8445B/0002/003			\$8100
	STORAGE NORMALIZER	8750			\$3930
	OSCILLOSCOPE	197B			\$1450
	CAMERA				
	EXTERNAL MIXER	11517A	12.4 to 40GHz		
	WAVEGUIDE TAPER	11518A	12.4 to 18GHz		\$275
	SECTIONS	"			
	"	11519A	18 to 26.5GHz		\$175
	"	11520A	26.5 to 40GHz		\$175
TEKTRONIX (15)	SPECTRUM ANALYZER	7L5	20Hz to 5MHz		\$6650 2 wks.
	"	7L13	1kHz to 1800MHz		\$9500 2 "
	"	491	10MHz to 40GHz		\$11,500 18 "
	INPUT IMPEDANCE L1		For 7L5		\$600 2 "
	MODULE				
	MAIN FRAME for		For 7L13		\$3430 17 "
	7L13				
AILTECH (4)	SPECTRUM ANALYZER	72711	1MHz to 20GHz		\$17,640 6 "
	SPECTRUM ANALYZER	757	1MHz to 22GHz		\$19,975 12 "
	S.A. Camera	46			\$450 6 "
GEN. MICROWAVE (25)	METER	4	.01 to 26GHz		\$1250 26 "
MARDA (14)	METER	8608	.01 to 26GHz		\$3645 16 "

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TABLE 1: TEST EQUIPMENT FOR TESTING TO MIL-STD-461A/462, NOTICE 3 1 and 2 (Continued)

MANUFACTURER	EQUIPMENT	MODEL	FREQUENCY RANGL	TEST NLT/OD	PRICE & DELIVERY
HEWLETT-PACKARD (7)	AMPLIFIER AMPLIFIER AMPLIFIER AMPLIFIER	489A 491C 493A 495A	1GHz to 2GHz 2GHz to 4GHz 4GHz to 8GHz 7GHz to 12.4GHz		\$3850. 9 wks \$3850. " \$4200. " \$4200. "
NARDA (14)	TWO-WAY POWER DIVIDER	3324-2 " "	2 to 3GHz 6 to 18GHz		\$225. 1 wk. \$350. 10 wks.
SOLAR (11)	LOW PASS FILTER	6623-0.1 " " " "	0 to 0.1MHz 0 to 0.2MHz 0 to 0.5MHz 0 to 1.0MHz 0 to 2.0MHz 0 to 5.0MHz 0 to 10MHz 0 to 20MHz 0 to 30MHz 0 to 50MHz 0 to 100MHz		\$295. 4 "
HEWLETT-PACKARD(7)	FREQUENCY COUNTER	5342A-H10	10Hz to 24GHz		\$4850
TEKTRONIX (15)	OSCILLOSCOPE, D. T. STORAGE OSCILLOSCOPE, PLUG-IN AMPLIF. " TIME BASE OSC. CART OSCILLOSCOPE CAMERA	7613 7A26 7B53A Model 3 C-53P	0 to 100MHz 0 to 200MHz, Dual		\$3430. 16 " \$1435. 6 " \$1135. 8 " \$375. 2 " \$1225
AMERICAN ELECTRON- IC LABS, INC. (24)	ANTENNA	ASN-1232	200 to 1000MHz		\$880. 1 wk.
HEWLETT-PACKARD(7)	ATTENUATOR	8491B-010	DC - 18GHz		\$95

TABLE 1: TEST EQUIPMENT FOR TESTING TO

MIL-STD-461A/462, NOTICES 1 and 2 (Continued)

MANUFACTURER	EQUIPMENT	MODEL	FREQUENCY RANGL	TEST METHOD												PRICE & DELIVERY	
				CE01	CE02	CE03	CE04	CE05	CE06	CE07	CE08	CE09	CE10	CE11	CE12		
ELECTRO-METRICS (2)	NOTCH FILTER NOTCH FILTER	NRG-10 NRF-10	400Hz 60Hz	x	x	x	x	x	x	x	x	x	x	x	x	\$410. \$860.	90 days " 90 "
SOLAR (11)	10MFD FEEDTHRU ISOLATION TRANSFORMER	6512-106R 7032-1	Power Line	x	x	x	x	x	x	x	x	x	x	x	x	\$60. \$100.	1 wk. 3 wks.
ELECTRO-METRICS (2)	CURRENT PROBE AMP.			x	x	x	x	x	x	x	x	x	x	x	x	\$425. \$17,000.	1 wk. 8 months
	TUNABLE REJECTION FILT.	TRF-11 TRF-12 TRF-13 TRF-14 TRF-15	14kHz to 220kHz 220kHz to 3500kHz 3.5MHz to 14MHz 14MHz to 110MHz 110MHz to 1000MHz													\$595. \$450.	90 days " 90 "
	HIGH PASS FILTER HIGH PASS FILTER	HPK-10 HPL-10	300Hz 2000Hz	x	x	x	x	x	x	x	x	x	x	x	x	\$890. \$890.	8 wks. 8 wks.
BIRD ELECTRONICS (22)	POWER ATTENUATOR (1KW)	8329	DC to 500MHz-30dB														
SOLAR (11)	AUDIO ISOLATION TRANSFORMER PHASE SHIFT NETWORK	6220-1A 7021-1	30Hz to 250kHz 60/400Hz	x	x	x	x	x	x	x	x	x	x	x	x	\$165. \$350.	6 wks. 1 wk.
BIRD ELECTRONICS (22)	DUMMYLOAD, 1KW	8251	DC to 1GHz													\$340. \$340.	10 wks. 10 wks.
NARDA (14)	ATTENUATOR, 20W ATTENUATOR, 20W	768-3 768-10	DC to 11GHz DC to 11GHz	x	x	x	x	x	x	x	x	x	x	x	x	\$140. \$140.	1 wk. " "
BIRD ELECTRONICS (22)	COAX SWITCH	7431														\$170. \$200.	4 wks. 1 wk.
NARDA (14)	COAX DIRECTIONAL COUPLER, 500 W 20 dB	3000-20	0.225 to 0.46 GHz													\$200. \$200.	2 wks. 10 wks.
		" "	0.46 to 0.95GHz	x	x	x	x	x	x	x	x	x	x	x	x	\$200. \$200.	1 wk. 8 wks.
		" "	0.95 to 2.0GHz	x	x	x	x	x	x	x	x	x	x	x	x	\$250. \$425.	2 to 4 GHz 4 to 10GHz 0.125 to 0.25GHz
		" "	2 to 4 GHz	x	x	x	x	x	x	x	x	x	x	x	x		
		" "	4 to 10GHz	x	x	x	x	x	x	x	x	x	x	x	x		
		" "	0.125 to 0.25GHz	x	x	x	x	x	x	x	x	x	x	x	x		

TABLE 1: TEST EQUIPMENT FOR TESTING TO

MIL-STD-461A/462, NOTICES 1 and 2 (Continued)

MANUFACTURER	EQUIPMENT	MODEL	FREQUENCY RANGL	TEST MILSTD				PRICE & DELIVERY
				CE01	CE02	CE03	CE04	
HEWLETT-PACKARD (7)	DIGITAL VOLT-METER	3435A	10kHz to 700MHz					200V/m
	RF PROBE	11096						\$400. 11 wks.
IFI (16)	FIELD SENSOR	EFS-1	10kHz to 200MHz					\$545. Stock
	LIGHT TX	LM	OPTICAL					\$445. "
	LIGHT RX	LDI						\$495. "
AMPLIFIER RESEARCH (17)	LEVEL AMP	777	10kHz to 300MHz					\$950. 2 wks.
TOPAZ (18)	TRANSFORMER		60Hz ISOLATION					\$275. Stock
BERKLEY (19)	SIGNAL SOURCE	3020	SPIKE					\$249. (GSA)
SOLAR (11)	SIGNAL SOURCE	6550-1	15Hz to 150kHz					\$1645. 4 wks.
	SIGNAL SOURCE	6254-1	SPIKE					\$1365. 3 "
	AMPLIFIER	6552-1A	25Hz to 125kHz					\$845. 3 "
AMPLIFIER RESEARCH (17)	AMPLIFIER	100 L	10kHz to 220MHz					\$750. 3 "
	AMPLIFIER	10W1000	1MHz to 16Hz					
ENI (20)	AMPLIFIER	1040L	10kHz to 500kHz					\$6700. 2 "
	AMPLIFIER	A150	0.3MHz to 35MHz					\$4900. 90 days
	AMPLIFIER	440LA	150kHz to 300MHz					\$2370. 60 "
	AMPLIFIER	601L	800kHz to 1GHz					\$3640. 60 "
IFI (16)	AMPLIFIER	M402	10kHz to 220MHz					\$4500. 60 "
ALLTECH (4)	AMPLIFIER	5001	10kHz to 10MHz					\$11,095. 60 "
	AMPLIFIER	5020	1 to 200MHz					
	AMPLIFIER	35512	100 to 520MHz					
	AMPLIFIER	15100	500 to 1000MHz					
HUGHES (21)	AMPLIFIER	1177H09	1 GHz to 2GHz					\$5640. 60 days
	AMPLIFIER	1177H01	2GHz to 4GHz					\$5640. 60 "
	AMPLIFIER	1177H02	4GHz to 8GHz					\$5640. 60 "
	AMPLIFIER	1177H17	7GHz to 16.5GHz					\$7695. 60 "

TABLE 1: TEST EQUIPMENT FOR TESTING TO

MIL-STD-461A/462, NOTICES 1 and 2 (Continued)

MANUFACTURER	EQUIPMENT	MODEL	FREQUENCY RANGL	TEST METHOD	PRICE & DELIVERY
MICROLAB (23)	POWER DIVIDER 2 Watt	DA-3FN CB-18N	DC - 2GHz 200 to 400MHz		\$55. 6 wks.
	DIRECTIONAL COUPLER, 20dB, 100W	CB-28N CB-38N CB-48N CB-68N CB-78N CB-88N	400 to 800MHz 750 to 1500MHz 1 to 2GHz 2 to 4GHz 4 to 8GHz 7 to 12GHz		\$200. 10 "
SOLAR (11)	LOOP SENSOR	7334-1	30Hz to 30kHz		\$195. 1 wk
	HIGH POWER SPIKE GENERATOR	7054-1	600 Volts		\$1450. 3 wks.
	RESISTOR, NON-INDUCTIVE	6920-0.5	0.5 OHM, 50 WATT	X	\$88. 1 wk.
	RESISTOR, NON-INDUCTIVE	6815-1	0.01 OHM, 50 AMP.	X X	\$185. 1 wk.

TABLE 2

EMI TEST EQUIPMENT CURRENTLY AVAILABLE AT NADC

DESCRIPTION	MODEL	MANUFACTURER
EMI Field Intensity Meter	NM-17/27	Singer Stoddard
EMI Field Intensity Meter	NB-37/57	Singer Stoddard
41" Rod Antenna	92197-3	Singer
Antenna Coupler	94592-1	Singer
Bi-Conical Antenna	7825	Honeywell
Bi-Conical Antenna	BCA-902	Honeywell
Conical Log Spiral Antenna	93490-1	Singer
Current Probe	91550-1	Stoddard
Tripod	91933-2	Singer
Transmission Cable, 20"	92191-1	Singer
H-Y Recorder	7047A	Hewlett-Packard
Line Stabilization Networks (3)	- -	- -
Loop Probe	90799-3	Singer
Impulse Generator	IG-115	Empire Devices

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TABLE 3
AILTECH EQUIPMENT REQUIRED TO EXTEND
CAPABILITIES OF PRESENT NADC EQUIPMENT

MANUFACTURER	EQUIPMENT	MODEL	UNIT PRICE	TOTAL PRICE	DELIVERY
AILTECH	CONTROL UNIT 20Hz - 50kHz	CP-7 NM-7A	\$25,000 9,560	\$25,000 9,560	18 weeks 12 "
	1-18GHz	NM-67	44,000	44,000	30 "
	Extend range to 40GHz; price not to exceed	FC-67	50,000	50,000	1 year
	INPUT SWITCH w. atten.	CIV-7	5,900	5,900	30 weeks
HEWLETT- PACKARD	CALCULATOR	9825F	9,000	9,000	18 "
	DIGITAL PLOTTER	9862.015	3,980	3,980	18 "
TEKTRONIX	OSCILLOSCOPE		3,400	3,400	18 "
AILTECH	LOOP ANTENNA 5 $\frac{1}{4}$ "d./NM-7	94605-1	235	235	12 "
	B.B. ANTENNA Preamp/Coupler	94607-1	500	500	8 "
	Biconical Antenna 20-200MHz	94455-1	595	595	8 "
	Log Periodic Antenna, 1-18GHz	94612-1	750	750	26 "
	Curr. Probe 20Hz-8MHz	91197-1	205	205	10 "
	Curr. Probe 1MHz-1GHz	94111-1	300	300	10 "
	Curr. Probe 20Hz-50MHz	93686-2	295	295	10 "
	BNC to N ADAPTER (2 ea.)	11663	6.50 ea.	13.	10 "

TABLE 3 (Cont'd.)

MANUFACTURER	EQUIPMENT	MODEL	UNIT PRICE	TOTAL PRICE	DELIVERY
AILTECH	CABLE 6', N-N	90933-6	\$ 75	\$ 75	10 weeks
	CABLE 20', N-N 2 ea.	90933-8	100	200	10 "
	CABLE 20' BNC-BNC	92191-1	45	45	10 "
	PROGRAM CABLE, 6'-4 ea.	94595-1	320	1280	10 "
	CABLE RF to VIDEO 8 ea.	94596-1	33	254	10 "
	CONTROL CABLE	94604-1	175	175	10 "
	CABLE-IEEE-488 10'	94618-2	185	185	10 "
	Cable -IEEE to Calculator	98034A	470	470	10 "
	TRIPOD ADAPTER, 2 ea.	91932	95	190	10 "
	TRIPODS, 2 ea.	91933-2	210	420	10 "
	GROUND PLANE	92199-3	90	90	10 "
	HEADPHONES	10796-2	33	33	10 "
	2 BAY CONSOLE/ DECK/STORAGE DRAWER (WIRED)		2700	2700	10 "
	ROLLAWAY CABINET WIRED FC67		1200	1200	10 "
	WAVEGUIDE for 18GHz-40GHz Ant.		300	300	10 "
	18-40GHz Ant.		750	750	10 "
	HORN ANTENNA KIT, 1-18GHz	94623-1	3575	3575	10 "
	HORN TRANSIENT CASE, 2 ea.	94621-1	225	450	10 "
			TOTAL PRICE	\$166,112	

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TABLE 4
RECOMMENDED ADDITIONAL EQUIPMENT
(BARE MINIMUM)

QUANTITY	MANUFACTURER	EQUIPMENT	MODEL	TOTAL PRICE
1	TENSOR (3)	ANTENNA	4105	\$1250
1	AILTECH (4)	CURRENT PROBE	91197-1	\$205
1	SOLAR (11)	CAPACITOR	7525-1	\$36.50
4		10MFD CAPACITOR	6512-106R	\$240.
2		ISOLATION XFMR	7032-1	\$200
1		AUDIO ISOLATION XFMR	6220-1A	\$165
1		SPIKE GENERATOR	7054-1	\$1450
1		0.5 ohm RESISTOR	6920-0.5	\$88
1		AMPLIFIER	6552-1A	\$750
1	HEWLETT-PACKARD (7)	ATTENUATOR	355D	\$255
1		SIGNAL SOURCE	8616A	\$4950
1		" "	618C	\$5850
1		" "	620B	\$5850
1		" "	626A	\$8650
1		" "	628A	\$8650
1		DIGITAL VOLTMET.	3435A	\$400
1		RF PROBE	11096	\$90
1		AMPLIFIER	489A	\$3850
1		"	491C	\$3850
1		"	493C	\$4200.
1	WAVETEK (8)	SIGNAL SOURCE	166	\$1695
1		" "	2002	\$3400
1	IFI (16)	FIELD SENSOR	EFS-1	\$545

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TABLE 4 (Continued)

QUANTITY	MANUFACTURER	EQUIPMENT	MODEL	TOTAL PRICE
1	AMPLIFIER RESEARCH (17)	LEVEL AMP	777	\$950
1		AMPLIFIER	100L	\$6700
1		"	10W1000	\$4900
"		"		
1	HUGHES (21)	AMPLIFIER	1177H17	\$7695
1	BIRD ELECTRONICS (22)	ATTENUATOR	8329	\$890
1		DUMMYLOAD	8251	\$340
1		COAX SWITCH	7431	\$170
"				
1	NARDA (14)	DIRECT. COUPLER	3000-20	\$200
1		"	3001-20	\$200
1		"	3002-20	\$200
1		"	3003-20	\$200
1		"	3004-20	\$250
1		"	3039-20	\$425
1	MICROLAB (23)	POWER DIVIDER	DA-3FN	\$55
1	ELECTRO-METRICS (2)	NOTCH FILTER	NRG-10	\$410
1		" "	NRF-10	\$860
1		TUNABLE REJ.	TRF-13	\$4200
1		FILTERS	TRF-14	\$3700
1		" "	TRF-15	\$3400
1	GENERAL MICROWAVE (25)	METER	4	\$1250
1	HEWLETT-PACKARD (7)	SPECTRUM ANALYZER	141T	\$2600
1		IF SECTION	8552B	\$4025
1		RF SECTION	8553B	\$3350
1		" "	8555A	\$8100
1		PRE-SELECTOR	8445B	<u>\$3930</u>
			TOTAL COST	\$110,434.50

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TABLE 5
RECOMMENDED ADDITIONAL EQUIPMENT
(PREFERRED)

QUANTITY	MANUFACTURER	EQUIPMENT	MODEL	UNIT PRICE	TOTAL PRICE
1	TENSOR (3)	ANTENNA	4104	\$485	\$485
1		ANTENNA	4101	\$495	\$495
1		ANTENNA	4105	\$1250	\$1250
1	ELECTRO-METRICS (2)	CURRENT PROBE	PCL-10	\$300	\$300
1		RECEIVER SYSTEM	PCL-25	\$305	\$305
1			CCS-125	\$74,795	\$74,795
2	HEWLETT-PACKARD (7)	SIGNAL SOURCE	200CD	\$730	\$1460
2		"	204D	\$540	\$1080
2		"	606B	\$4500	\$9000
2		"	608E	\$5800	\$11,600
2		"	612A	\$4650	\$9,300
2		"	8614A	\$4950	\$9,900
2		"	8616A	\$4950	\$9,900
2		"	618C	\$5850	\$11,700
2		"	620B	\$8650	\$17,300
2		"	626A	\$8650	\$17,300
2		"	628A	\$8650	\$17,300
1	SOLAR (11)	TRANSFORMER	6220-1A	\$99.50	\$99.50
1		CAPACITOR	7525-1	\$36.50	\$36.50
4		FEEDTHRU	6512-106R	\$59.50	\$238

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TABLE 5 (Continued)

QUANTITY	MANUFACTURER	EQUIPMENT	MODEL	UNIT PRICE	TOTAL PRICE
1	HEWLETT-PACKARD (7)	ATTENUATOR	355D	\$255	\$255
1		ATTENUATOR	355C	\$255	\$255
2	NARDA	(14) ATTENUATOR	771-6	\$40	\$80
1	HEWLETT-PACKARD (7)	DIGITAL VOLTmeter	3435A	\$400	\$400
1		RF Probe	11096	\$90	\$90
1	IFI	(16) FIELD SENSOR	EFS-1	\$545	\$545
1		LIGHT TX	LMT	\$495	\$495
1		LIGHT RX	LDI	\$495	\$495
1	SOLAR	(11) SIGNAL SOURCE	6254-1	\$845	\$845
1		AMPLIFIER	6552-1A	\$750	\$750
1	AMPLIFIER RESEARCH (17)	AMPLIFIER	100 L 10W1000	\$6700 \$4900	\$6700 \$4900
1	HUGHES (21)	AMPLIFIER	1177H09	\$5640	\$5640
1		AMPLIFIER	1177H01	\$5640	\$5640
1		AMPLIFIER	1177H02	\$5640	\$5640
1		AMPLIFIER	1177H17	\$7695	\$7695
1	ELECTRO-METRICS (2)	NOTCH FILTER	NRG-10	\$410	\$410
1		NOTCH FILTER	NRF-10	\$860	\$860
2	SOLAR (11)	ISOLATION TRANSFORMER	7032-1	\$100	\$200

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TABLE 5 (Continued)

QUANTITY	MANUFACTURER	EQUIPMENT	MODEL	UNIT PRICE	TOTAL PRICE
1	ELECTRO-METRICS	(2) CURRENT PROBE AMP.		\$425	
1		TUNABLE REJECTION FILT.	TRF-11 TRF-12 TRF-13 TRF-14 TRF-15		
1		HIGH PASS FILTER	HPK-10 " " HPL-10	\$595 \$450	
1	BIRD ELECTRONICS	(22) POWER ATTENUATOR (1kw)	8329	\$890	
1	SOLAR	(11) PHASE SHIFT NETWORK	7021-1	\$350	
1	BIRD ELECTRONICS	(22) DUMMY LOAD, 1kw	8251	\$340	
2	NARDA	(14) ATTENUATOR, 20W ATTENUATOR, 20W	768-3 768-10	\$140 \$140	\$280 \$280
1	BIRD ELECTRONICS	(22) COAX SWITCH	7431	\$170	
1	NARDA	(14) COAX DIRECTIONAL COUPLER, 500W 20dB	3000-20 " " " " 3001-20 " " " " 3002-20 " " " " 3003-20 " " " " 3004-20 " " " " 3039-20	\$200 \$200 \$200 \$200 \$200 \$250 \$425	

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TABLE 5 (Continued)

QUANTITY	MANUFACTURER	EQUIPMENT	MODEL	UNIT PRICE	TOTAL PRICE
1	MICROLAB	(23)	POWER DIVIDER 2 Watt	DA-3FN \$55	\$55
1	SOLAR	(11)	LLOOP SENSOR	7334-1 \$195	\$195
1			RESISTOR, NON-INDUCTIVE	6920-0.5 \$88	\$88
1			" "	6E15-1 \$185	\$185
1	NARDA	(14)	TWO-WAY POWER DIVIDER	3324-2 3326-2 \$225 \$350	\$225 \$350
2	SOLAR	(11)	LOW PASS FILTER	6623-0.1 6623-0.2 6623-0.5 6623-1.0 \$295 \$295 \$295 \$295	\$295 \$295 \$295 \$295
2			" "	6623-2.0 6623-5.0 6623-10 6623-20 \$295 \$295 \$295 \$295	\$295 \$295 \$295 \$295
2			" "	6623-30 6623-50 6623-100 \$295 \$295 \$295	\$295 \$295 \$295
1	HEWLETT-PACKARD	(7)	FREQUENCY COUNTER	5342A-H10 \$4850	\$4850
1	TEKTRONIX	(15)	OSCILL., D.T.		
			STORAGE OSCILL., PLUG-	\$3430	\$3430
			IN AMPLIF.	\$1435	\$1435
			PLUG-IN TIME BASE	\$1135	\$1135
			OSCILL. CAMERA	\$1225	\$1225

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TABLE 5 (Continued)

QUANTITY	AMNMANUFACTURER	EQUIPMENT	MODEL	UNIT PRICE	TOTAL PRICE
2	HEWLETT-PACKARD (7)	ATTENUATOR	8491B-010	\$95	\$190
1	AMERICAL ELECTRONIC LABS, INC. (24)	ANTENNA	ASN-1232	\$880	\$880
1	HEWLETT-PACKARD (7)	MAIN FRAME/ DISPLAY	141T	\$2600	\$2600
1		IF SECTION	8552B	\$4025	\$4025
1		RF SECTION	8556A	\$2525	\$2525
1		" "	8553B	\$3350	\$3350
1		" "	8555A	\$8100	\$8100
1		PRESELECTOR	8445B/002/003	\$3930	\$3930
1		STORAGE NORMALIZER	8750	\$1450	\$1450
1		OSCILLOSCOPE CAMERA	197B	\$1100	\$1100
1		EXTERNAL MIXER	11517A	\$275	\$275
1		WAVEGUIDE TAPER SECTIONS	11518A	\$175	\$175
1		" "	11519A	\$175	\$175
1		" "	11520A	\$175	\$175
1	GENERAL MICROWAVE (25)	METER	4	\$1250	\$1250
1	ELECTRO-METRICS (2)	ANTENNA	RV/R-25	\$990	\$990
			TOTAL PRICE		\$303,247.00

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TABLE 6
EQUIPMENT MANUFACTURER
LOCATION

(1) The Electro-Mechanics Co. (EMCO)	P. O. Box 1546	Austin, TX 78767	512-451-8273	(9) KROHN-HITE Corp.	Avon Industrial Park	Bodwell St.	Avon, MA 02322	617-580-1660
(2) Electro-Metrics	100 Church St.	Amsterdam, NY 12010	518-843-2600	(10) Genisco Technology Corp.	18435 Susana Rd.	Compton, CA 90221	213-537-4750	
(3) Tensor, Inc.	P. O. Box 14843	Austin, TX 78761	512-837-4900	(11) Solar Electronics Co.	901 N. Highland Ave.	Hollywood, CA 90038	213-462-0806	
(4) AILTECH	Los Angeles Operation	5340 Alla Rd.	Los Angeles, CA 90066	(12) Captor Corporation	5040 S. County Rd. (25A)	Tipp City, OH 45371	513-667-8484	
(5) Fischer Custom Communications	P. O. Box 581	Manhattan Beach, CA 90266	213-545-4617	(13) Filtron Mfg. Co., Inc.	148 Sweet Hollow Rd.	Old Bethpage, NY 11804	516-752-1144	
(6) Watkins-Johnson Co.	700 Quince Orchard Rd.	Gaithersburg, MD 20760	301-948-7550	(14) Narda Microwave Corp.	75 Commercial St.	Plainview, NY 11803	516-433-9000	
(7) Hewlett-Packard Co.	1021 Eight Ave.	King of Prussia, PA 19406	215-265-7000	(15) Tektronix, Inc.	P. O. Box 500	Beaverton, OR 97077	503-644-0161	
(8) Wavetek	66 North First Ave.	Beech Grove, IN 46107	317-783-3211	(16) Instruments for Industry, Inc.	151 Toledo St.	Farmingdale, NY 11735	516-694-1414	

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TABLE 6 (Cont'd.)

(17) Amplifier Research Corp. 160 School House Rd. Souderton, PA 18964 215-723-8181	(27) EPSCO Microwave 411 Providence Hwy. Westwood, MA 02090 617-329-1500
(18) Topaz Electronics 3855 Ruffin Rd. San Diego, CA 92123	(28) Logimetrics, Inc. 121-03 DuPont St. Plainview, NY 11803 516-681-4700
(19) Berkeley Instruments, Inc. 2700 DuPont Dr. Irvine, CA 92715	
(20) Electronic Navigation Industries, Inc. 3000 Winton Rd. So. Rochester, NY 14623 716-473-6900	
(21) Hughes Aircraft Co. Electron Dynamics Div. 3100 W. Lomita Blvd. Torrance, CA 90509 213-534-2121	
(22) Bird Electronics Corp. 30303 Aurora Rd. Solon, OH 44139 216-248-1200	
(23) Microlab/FXR 10M Microlab Rd. Livingston, NJ 07031 201-992-7700	
(24) American Electronic Labs, Inc. P. O. Box 552 Lansdale, PA 19446 215-822-2929	
(25) General Microwave Corp. 155 Marine St. Farmingdale, NY 11735 516-694-3600	
(26) BEC Engineers, Inc. 625 Andover Park West Tukwila, WA 98188 206-575-5772	

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TABLE 7
RADIATION HAZARD MONITORING INSTRUMENTS

MANUFACTURER	EQUIPMENT	MODEL	FREQUENCY RANGE	PRICE	DELIVERY
NARDA MICROWAVE (14)	METER	8608	0.01 to 26GHz		
	PROBE	8621	0.3 to 26GHz	\$3645	16 weeks
	PROBE	8631	10 to 300MHz		
	PROBE	8623	0.3 to 26GHz	\$1450	18 weeks
	PROBE	8633	10 to 300MHz	\$975	12 weeks
*GENERAL MICROWAVE(25)		4	0.01 to 26GHz	\$1250	26 weeks

*Recommended because of price.

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TABLE 8
EQUIPMENT FOR 200V/M SUSCEPTIBILITY TEST

MANUFACTURER	EQUIPMENT	MODEL	FREQUENCY RANGE	POWER	PRICE	DELIVERY
AMPLIFIER RESEARCH (17)	POWER AMPLIF.	AR2000L	10kHz to 220MHz	2kW	\$38,000	4 months
	"	AR900	10kHz to 100MHz	10kW	\$75,000	9 "
	"	AR200HA	220 to 400MHz	200W	\$15,900	4 "
EPSCO MICROWAVE (27)	POWER SOURCE	5233H/B3	450 to 950MHz	5kW Pulse	\$7000	8 weeks
LOGIMETRICS (28)	POWER AMPLIF.	A600/L A600/S A600/C A600/X A600/U	1 to 2GHz 2 to 4GHz 4 to 8GHz 8 to 12.4GHz 12.4 to 18GHz	200W 200W 200W 200W 100W	\$20,000 \$18,500 \$18,500 \$19,000 \$30,500	150 days
AMPLIFIER RESEARCH (17)	ANTENNA	AT1000	150 to 1000MHz		\$1850	60 "
TENSOR (3)	RIDGED WG. ANT.	4105	1 to 12.4GHz		\$1250	90 days
AMERICAN ELECTRONIC LABS., INC. (24)	LOG PERIODIC ANTENNA					
BOEING (26)	TEM TEST CELL		10kHz to 100MHz		\$1- 3,000,000	
LOGIMETRICS (28)	200V/M SYSTEM COMPLETE-INSTALLED W/REMOTE CONTROL	1018R	10kHz to 27GHz	200V/M at 1 Meter	\$600,000	1 year
	200V/M SYSTEM COMPLETE-INSTALLED COMPUTER CONTROL W/ SOFTWARE				\$850,000	1 year